NEWSLETTER

PRIVATE CIRCULATION VOLUME 14 NUMBER 3 SUMMER 1977

AUSTRALIAN SOCIETY FOR LIMNOLOGY
NEWSLETTER

VOLUME 14 NUMBER 3 AUTUMN 1977

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THE AUSTRALIAN SOCIETY FOR LIMNOLOGY

The Australian Society for Limnology is an association of over 200 people with professional or amateur interests relating to Australian inland waters. Since its inception in 1961, the Society has played an important role in fostering limnological work in this country. The ASL also promotes liaison between limnologists in academic, private, and governmental institutions, and has a vested interest in the conservation of aquatic and related resources. Annual congresses are held near centres of limnological interest, and the program includes scientific sessions, field excursions, and social activities.

The ASL produces a Newsletter, with notes on activities, articles of general interest, book reviews, and congress announcements, and an occasional Special Publication. A further periodical publication is the Directory of Australian Limnologists.

Membership applications are welcomed; four classes of subscribing membership are catered for:

- Ordinary members ($8 pa)
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- Sustaining members ($50 pa or more)
- Affiliated Bodies (subs. on application)

NOTE: Members are entitled to receive the *Aust. J. Mar. Freshwat. Res.* at a reduced rate ($4).

Subscriptions cover the period 1 July-30 June.

Details are available from:

Dr. R.T. Buckney,
Hon. Sec./Treasurer, ASL,
Department of Zoology,
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* * * * *

Newsletter contributions are always welcome, and correspondence should be addressed to the Newsletter Editor. The next copy deadline is July 1, 1977.

EDITOR'S NOTE

Most of you will have noted the discrepancy between the actual and stated dates of appearance of the last Newsletter. Many will also have been impatient over the delay in providing details of the forthcoming Lismore Congress due to the late birth of the last Newsletter. I owe you all an apology: yes, it was very late, and yes I am sorry! The explanation: in an effort to save the Society some money an attempt was made to have the Newsletter multilithed by the Department of *#@!/?&*. As in all endeavours of that department, they had trouble in meeting deadlines. Eventually I loaded my double-barrel and demanded the manuscript back or else. I got the manuscript. It was then produced by the #!?/@%* using as slave labour all available Uni. Adel. limnos. This number is produced in the same way. It may not be too hot as far as its quality of production is concerned, but by God its intellectual quality is fantastic, and it is on time.

See you Lismore,

W.D.W.

WANTED ALIVE

MICRASTERIAS

PLEUROTAENIUM

TRIPLOCERAS

Sue Blackburn, Botany Department, University of Tasmania, would be grateful for live specimens of the above desmid algae for culture and crossing with virulent Tasmanian strains.

For the uninitiated, the organism on the front cover of this Newsletter is a species of *Micrasterias*.

* * * * *

WATER AS A RESOURCE

The following item of news will be of some interest to members. Please note the deadline for receipt of submissions.

MOTION PASSED IN THE SENATE OF THE COMMONWEALTH OF AUSTRALIA ON THE 8TH DECEMBER, 1976

That the following matter be referred to the Standing Committee on National Resources for enquiry and report:

The Commonwealth's role in the assessment, planning, development and management of Australia's water resources having particular regard to:

(1) The diverse responsibilities of the Commonwealth and the States, and

(2) the National Water Policy Statement recently endorsed by the Australian Water Resources Council.

Submissions on this matter will be invited and should reach the Secretary of the Committee* by 29th April, 1977.

*Australian Water Resources Council, Canberra.

* * * * *

AUSTRALIAN JOURNAL OF MARINE AND FRESHWATER RESEARCH

The following extract from the minutes of the Editorial Advisory Committee to the *Aust. J. Mar. Freshwat. Res.* will be of interest to members of the Society (meeting held Cronulla, N.S.W., 2 Sept., 1975):

> "Professor Williams said that there seemed to be a bias against acceptance of taxonomic papers on aquatic insects in the Journal, and emphasized the important role of insects of the aquatic environment in the food chain. After discussion the Committee agreed to the following statement:
>
> > 'This Committee noted the paucity of papers on aquatic entomology in the Journal but this was not to be taken as an indication of a policy decision of the Committee.' "

The matter was discussed further at the most recent meeting of the Editorial Advisory Committee (Melbourne, 3 Feb., 1977). Following this a letter was sent to Professor Williams (as ASL Newsletter Editor) by Mr. Walby, Editor-in-Chief of the *Aust. J. Mar. Freshwat. Res.* The relevant part reads:

> "The minutes of the Advisory Committee meeting instruct me to write to you as Editor of the *Australian Society for Limnology Newsletter* to point out the entry in the 1975 minutes referring to the paucity of papers on aquatic entomology in the *Australian Journal of Marine and Freshwater Research*. I must, however, say that we do not wish to flood the journal with long taxonomic papers and would prefer to publish marginally aquatic papers in the supplements to the *Australian Journal of Zoology*."

The various matters concerning the *Aust. J. Mar. Freshwat. Res.* raised by Dr. George Ganf at the 1976 Congress were also considered by the Advisory Committee. On the question of anonymity or otherwise, Mr. Walby replied as follows:

> "We respect the referee's anonymity unless specifically requested to make the referee's name known to the author as an aid to discussion and improvement of a submitted paper."

My interpretation of this is that referees remain anonymous unless they want not to be. The onus lies upon the referee.

* * * * *

DR. TOMI PETR

Tomi has made quite an impression on the limnological scene since his advent here. However, it looks as if we are to lose him to our near northern neighbour shortly. Here is an abstract of a recent letter from him to your Editor:

> "This time the rumours are right. Indeed, I have signed a two-year contract with the Commonwealth Secretariat (CFTC) and will depart on 25 February 1977 for Papua New Guinea. My official title will be: Environmental Manager - Purari Scheme. I shall be attached to the Office of Environment and Conservation, Central Government Offices, Waigani, Papua New Guinea (this is also my address from 25 February 1977). The Purari Scheme is a proposal to build a cascade of dams in this catchment. The post is quite challenging, and I am looking forward to it."

* * * * *

WATER AS A BASIC RESOURCE

We all know, as limnologists, that Australia is the driest continent. Here are some recent suggestions that appeared in the press to mitigate our shortage of water:

- Use a rug when you shower then haul it outside and wring it over the flowerbeds. This will encourage showering with a friend, since you'll need two people to carry the wet rug.
- Bathe your dog in your bath water. You save soap as well as water. Take your bath first if you wish .....
- Scrape the condensation off your cocktail glass on to house plants. The amount of water you save, of course, depends on how many cocktails you drink.
- Cancel all out-of-State visitors, especially inlaws.
- Breed piranhas in the bathtub.

POLLUTION

And we all know of that famous example in North America of a river that was so badly polluted that it is a fire hazard. We now have our own example:

> SYDNEY, Tuesday. -
>
> Oil and chemical pollution on the surface of a creek which runs through the Peakhurst-Mortdale factory area was so thick it was ignited by a grass fire last night.
>
> (From the *Canberra Times*, Wednesday Feb. 16, 1977)

ARTICLES

CHEMICAL ASPECTS OF ACID MINE WASTE POLLUTION IN THE DAWESLEY-NAIRNE CREEK SYSTEM, SOUTH AUSTRALIA*

By G. Chittleborough

(Adelaide, C.A.E., Kintore Ave., Adelaide)

Synopsis

The research investigates chemical aspects of the Dawesley-Nairne Creek system which is polluted by heavy metals, light metals, sulphuric acid and organic (sewage) effluents.

Samples of the leaves of *Eucalyptus camaldulensis* lining the bank and sediments from the stream were analysed for heavy metals.

1. Introduction

The Brukunga Mine, about 5.5 km north of Nairne in the Mt. Lofty Ranges was closed in 1972, having operated since 1955 for the open cut mining of the sulphur-bearing minerals pyrite (FeS_2) and pyrrhotite (Fe_7S_8). The mine runs for some 2,000 metres parallel to the western bank of the Dawesley Creek. The overburden from the quarry benches forms two mullock dumps on one bank of this creek, while on the other side is a tailings dam (area *ca.* 27 ha) constructed for treating the slurry of mineral residues. Figure 1 illustrates the features of the locality.

Water draining the mine, the dam and the dumps has a low pH and relatively high concentrations of heavy metal ions (Blesing *et al.* 1974). This "acid drainage" pollutes the waters of Dawesley Creek. The work of Blesing *et al.* (subsequently referred to as that of Blesing) showed that the acidity and heavy metal pollution was still detectable during winter flow at the junction of the Dawesley and Mt. Barker Creeks, a distance of over 16.5 km. Blesing's work was restricted to measurement of chemical species and no biological study was conducted.

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* An edited version of a report submitted for the Limnology Unit of the Master of Environmental Studies course, University of Adelaide. The help of Dr. R.T. Buckney in preparing this article for the Newsletter is gratefully acknowledged.

ED.

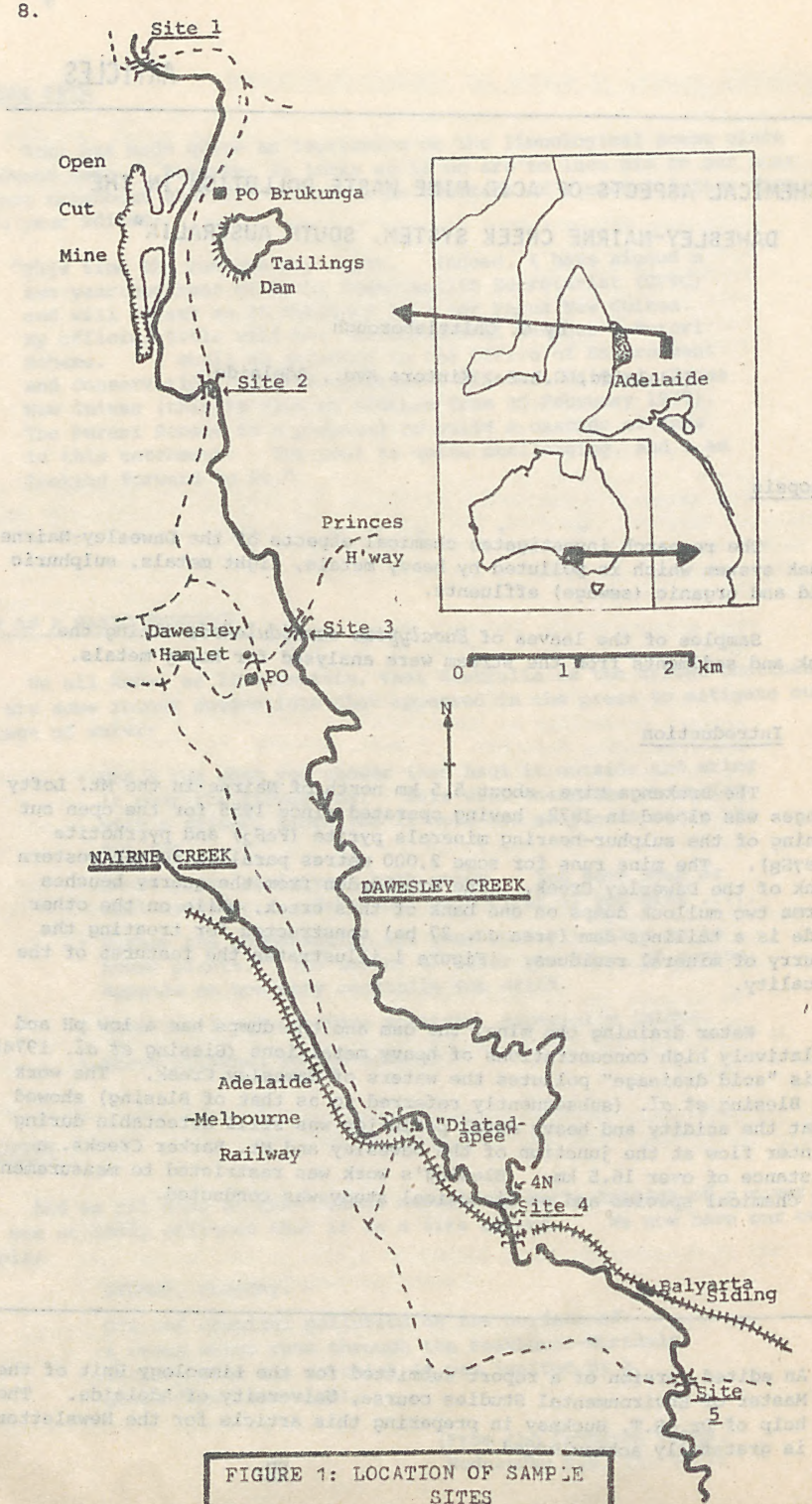

FIGURE 1: LOCATION OF SAMPLE SITES

2. The chemistry of the origin of the acid drainage

The weathering of the principal economic minerals of the mine, pyrite and pyrrhotite, involves oxidation by moist air. Initially ions of iron (II), sulphate and hydrogen are produced.

$$FeS_2 + H_2O + 7\ (O) \longrightarrow Fe^{2+} + 2H^+ + 2SO_4^{2-}$$

pyrite

$$Fe_7S_8 + H_2O + 31\ (O) \longrightarrow 7Fe^{2+} + 2H^+ + 8SO_4^{2-}$$

pyrrhotite

Oxidation of iron (II) can be accelerated by the enzymatic activity of bacteria (Jones 1976):

$$2Fe^{2+} + 2H^+ + (O) \xrightarrow{\text{Th. ferrooxidous}} 2Fe^{3+} + H_2O$$

The iron (III) reacts with more mineral to regenerate iron (II) with the release of free sulphur from which more sulphuric acid solution is formed, assisted by the bacterium Th. thiooxidous.

$$2Fe^{3+} + FeS_2 \qquad 3Fe^{2+} + 2S$$

$$S + H_2O + 3\ (O) \xrightarrow{\text{Th. thiooxidous}} 2H^+ + SO_4^{2-}$$

Also present in smaller quantities amongst the main minerals are other sulphides of Zn, Cu, Co and Ni, all of which react with iron (III), as above. These reactions may thus lead to the relatively high concentrations of heavy metal ions. The acid formed by such oxidations is able to attack silicates in the host rock releasing a number of other metal ions including Al^{3+}, K^+, Na^+, Ca^{2+} and Mg^{2+}.

Clearly the acid drainage contains a considerable variety and quantity of inorganic species in solution.

3. Results and Discussion

Analyses are presented in Table 1.

Sample sites are shown in Fig. 1; sites 4A, 4B and 4C are respectively 20 m upstream, 20 m downstream and 40 m downstream of site 4. Site 4N was selected as being representative of the Dawesley at a time when the Nairne was back-washing into the Dawesley. Sites approximately correspond to those used by Blesing *et al.* (1974).

On the first visit to the area sites 1, 2, 3 and 4 were visited and sampled. Field measurements of pH at sites 1, 2 and 3 corresponded with those of Blesing. At these sites the stream biota appeared to be virtually non-existent. The only living biota discovered were green algae and a sedge (*Scirpus* sp.). Observations at site 4A were, by contrast, at odds with those of Blesing. The present researcher found the waters to be neutral to alkaline with aquatic fauna conspicuously in evidence; Blesing reported quite acid waters (pH = 3.45). At this time it appeared that Nairne Creek was flushing water up the Dawesley channels so results for site 4 were strictly for Nairne Creek.

On a second visit to the area sediment samples were collected. Leaves of the tree *Eucalyptus camaldulensis* were also taken. These were analysed for their metal content; the results are shown in Table 1.

TABLE 1. Analyses of water, sediments and leaves in the Dawesley-Nairne Creek System

Part A. Water Analyses

Site	1	2	3	4N	4A	4A	4D	4C	5
pH (2.6.76)	6.7	3.1	3.05	-	8.3				
pH (11.6.76)	7.85	3.2	3.08	3.15		3.4	8.5	4.1	7.4
	←		2.6.76	→		←		11.6.76	→
Cu (ppm)	0.0	0.92	0.60	0.66	0.0	0.58	0.16	0.37	0.03
Fe "	0.0	31	39	17	0.0	6.4	0.0	1.2	0.0
Mn "	0.0	24	30	42	0.1	24.	0.0	30	0.7
Zn "	0.01	26	39	44	0.0	41	0.0	24	0.2
dissolved O_2 (mg l^{-3})	2.4[a]	9.5[a]	10.8[a]	-	10.2[b]	-		10.3[a]	
	1.7[b]	10.1[a]	10.6[b]	-		-		4.7[b]	
		3.5[b]							

a = riffle; b = pool or still water

Part B. Leaves

Weights of metal present (µg) in 1 g dried leaf sample

Site	1	2	3	4N	4C	5
Cu	13	15	27	20	11	31
Fe	361	83	251	215	100	209
Mn	780	2410	1460	600	930	1170
Zn	100	310	141	564	400	140

Part C. Sediments

Weights of metal present (µg) in 1 g dried sample

Site	1	2	3	4N	4BC	5
Cu	22	72	98	26	97	191
Fe	18000	69000	35500	49000	188000	73000
Mn	69	219	75	37	81	146
Zn	48	296	112	143	198	386

On this second visit, spectacular visual evidence of Dawesley flow at site 4A was discovered at the junction of the two streams. As the waters of the two streams met, a thick white precipitate was forming at a sharply defined, almost vertical, interface. On one side of this interface the pH of the clear Nairne waters was 8.5; on the other side lay curds of white precipitate. Within a metre of this point and on the Dawesley side the pH was 5.0 and within another metre it was 4.2. A few metres upstream in the Dawesley the pH of the surface waters was back to 3.3. Here evidence of incomplete mixing of the two streams could be observed by stirring the "potion" whereupon white wisps of precipitate were created as the two liquids mixed. Several metres downstream a large body of white flocculated solid could be seen near site 4B. Further downstream at 4C the now mixed and reacted waters had a pH of 4.1.

3.1 Chemistry of the observed precipitation

Blesing's work shows that quite high concentrations of both aluminium and iron were present in the waters of Dawesley Creek just downstream of the mine. The white solid is very probably a precipitate of aluminium hydroxide rather than ferric hydroxide, despite the ubiquitous coatings of ferric hydroxide in riffle areas.

The solubility products (K_{5p}) and concentrations of metal ions M^{3+} or M^{2+} involved are:

	K_{5p}*	M^{3+}
$Fe(OH)_3$	4.0×10^{-40}	6.2×10^{-11}
$Al(OH)_3$	1.0×10^{-33}	2.5×10^{-9}
$Fe(OH)_2$	4.8×10^{-6}	3.8×10^{-6}

*Data from Aylward, G.H. and Finalay, T.J.V., "Chemical Data Book" (Wiley) 1966.

The figures indicate that $Fe(OH)_3$ will precipitate preferentially in the presence of Fe^{3+}, Al^{3+}. Normally iron exists in nature as Fe^{3+} rather than Fe^{2+}. If, however, iron is present only as Fe^{2+}, then the figures indicate that Al^{3+} will precipitate preferentially. It seems that at the time of observation this was the state of the Dawesley water. The reason for this appears to lie in the presence of organic pollutants in the waters of both streams. This can be understood by considering the Standard Reduction Potentials:

Half-Reaction	E^o (volt)
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.77
$O_2 + 4H^+ + 4e^- \rightarrow 4H_2O$	1.23
$CO_2 + 2H^+ + 2e^- \rightarrow (COOH)_2$ oxalic acid	-0.49

In acid solution, oxygen can convert organics (such as oxalic acid, chosen for convenience) to carbon dioxide. Organics may also reduce ferric species to ferrous. Clearly then in a eutrophic system such as obtained in the stream waters, a heavy organic load could convert iron present to Fe^{2+} having removed some or all of the oxygen in a calm or pool situation. The dissolved oxygen values obtained illustrate clearly how agitation in riffle areas can increase the amount of dissolved oxygen, albeit temporarily in the eutrophic condition of the stream.

3.2 Observations at Site 5

The flow of the Dawesley waters beyond site 4 prompted sampling at a fifth site downstream. The stream flowing under the ford was slightly alkaline (pH = 7.5). In a shallow pool, pH was 7.4. About 40 m downstream a white scum reminiscent of site 4 could be seen on the bottom of another shallow pool. Here the pH was 7.75. These alkaline values were puzzling in view of the flow of water at the ford. A possible explanation could be offered in terms of the flow of some alkaline ground water into the stream.

3.3 General

The effects of acid drainage on the pH can be clearly seen at sites 2, 3 and (on 11.6.76) at 4; these values correspond well with those obtained by Blesing. The effect on site 5 has been discussed already.

As expected there is a clear correlation between water acidity and metal concentration. The higher pH values at sites 4 and 5 provide evidence of the insolubility of these metal species in alkaline waters.

Comparing the metal concentrations obtained in this research with the relevant values obtained by Blesing, the respective concentrations at sites 2, 3 and 4 for Fe are similar; those for Cu, Mn and Zn are 2-3 times higher in the somewhat more acidic conditions prevailing.

3.4 Metals in dry leaf samples

First, the site 1 sample (i.e. one not having access to the acid drainage water) shows no marked dissimilarity with those of the other sites. It would appear that the stream conditions have had very little effect on the uptake of heavy metals by the leaves.

Second, the concentrations of Mn seemed high. However, the paper of Bhimaya and Kaul (1966) contains data for *E. camaldulensis* growing at Pali, Rajasthan, India, which show Mn concentrations in (fresh?) leaves at up to 1000 ppm. Allowing for the water content of these leaves, the value is comparable with that obtained in this research for site 2 (2410 µg per gram).

The absolute values of the metal concentrations in the leaves may not be especially meaningful, but it is of interest to consider the relative weights of the elements in a given sample. If metal concentrations are expressed as a proportion of the Cu concentration, the "Indian form" of *E. camaldulensis* seems to follow the "Dawesley form" to the extent of having quite similar proportions of Fe to Cu, but the relative weights of Mn and Zn to Cu are much less. It is tempting to suggest that the "Dawesley forms" of the eucalypt are concentrating Mn and to a lesser extent Zn.

3.5 Metal concentrations in dry sediments

The most obvious point of comment is the large amount of iron present. This is not uncommon in sediments of other streams and lakes affected by acid drainage. Lake Burley Griffin and the Molonglo River are examples (Joint Government Technical Committee, 1974).

Apart from sites 1 and 4B,C the iron ranges from 3.5 to 7.3 per cent. The low value of 1.8% at site 1 indicates that iron present in the acid drainage has entered the sediments further downstream. The sample at 4B,C, showing nearly 19% Fe must be considered separately. The sample was an orange-red colour characteristic of rust - indeed it looked like "pure" ferric hydroxide precipitate. Assuming that ferric hydroxide is $Fe(OH)_3(H_2O)_3$, then the percentage of Fe is 34.8%. The least possible proportion of $Fe(OH)_3(H_2O)_3$ in the sample is thus 54% and is very probably much more. This calculation bears witness to the fact that ferric hydroxide may precipitate in very substantial amounts in the stream.

As in the case of the leaves it is of interest to consider the relative weights of the metals Fe, Mn and Zn to a unit weight of Cu.

Considerations of iron aside, it appears that the proportions of Cu, Mn and Zn in the sediments are unaffected by the "supernatant" waters. Cu, Fe, Mn and Zn in the sediments at site 1 have arrived through geological processes preceding the occurrence of acid drainage. The other sediments at sites 2, 3, 4 and 5 show generally higher levels of metals indicating a contribution from the acid drainage.

Acknowledgements

It is a pleasure to acknowledge my gratitude to Warren Jones, a fellow student who drew my attention to the problem of Dawesley Creek, and to Drs. J. Bishop and R. Buckney for advice and cooperation.

References

Bhimaya, C.P. and Kaul, R.N. (1966). Levels of Macro and Micro elements in *Eucalyptus camaldulensis* Dehn. (*E. rostrata* Schlect.). *Nature* 212: 319.

Blesing, N., Lackey, J. and Spry, A. (1974). Rehabilitation of an abandoned mine site. Paper 16, International Symposium on Minerals and the Environment.

Brougham, H.L. (1976). The accumulation of Fe, Zn, Cu and Mn in molluscs and plants in the Onkaparinga River, S.A. Unpublished report in Limnology Unit, University of Adelaide.

Filsell, W. (1975). Brukunga - the problem of an abandoned mine. An unpublished paper prepared for the course Ecology of Man and Society, Flinders University.

Jones, J. (1976). Application of Weathering Studies. Modification of man-made structures and the landscape. Lecture 13 notes. Environmental Geoscience Course, University of Adelaide.

Joint Government Technical Committee (1974). Mine Waste Pollution of the Molonglo River. (Australian Government Printing Service, Canberra.)

THE LIMNOLOGY OF FARM DAMS *

By B.V. Timms

(Science Dept., Avondale College, Cooranbong, N.S.W. 2265)

Abstract

Farm dams are highly variable limnologically, but typically they are very turbid, usually unstratified, and greatly influenced by inflows. Phytoplankton and zooplankton are of variable composition in space and time; nuisance blooms may occur. Littorals may be bare of vegetation and benthos sparse even in old dams, but in many the littoral is well vegetated and benthos abundant. Fish and yabbies can be reared successfully. Obvious ecological succession occurs in most farm dams, but details are lacking.

The chief factors affecting the limnology of farm dams appear to be, in order, land use patterns, catchment characteristics and climate.

More study is needed to enable and to encourage the multi-purpose use of farm dams.

Introduction

Although dams on farms are extremely numerous throughout much of Australia, we know little of their limnology. This is surprising as dams comprise fairly discrete ecosystems, many are readily accessible and there is a wide variety for study. On the other hand, the limited manpower available has been directed to sites thought to be more interesting and furthermore, some researchers may have been repulsed because of Elton's comments (in Macan, 1963) on the variability of pond communities. But dams provide habitat for fish and yabbies, so if nothing else, they have potential for recreational fishing and as a food source.

It is significant within the framework of this symposium that Australian farm dams were first studied seriously in Tasmania. Dr. Weatherley then of the C.S.I.R.O., investigated a number of dams near Hobart with particular reference to fish culture. His results were published in 1958. Since then there has been further work on fish and yabbie culture, some studies on physiochemical features and zooplankton, but little on other biological aspects. Hence I have found it difficult to present a balanced review. Furthermore, dams vary tremendously so it is often dangerous to generalize.

Geography and Geomorphology

There could be 250,000 or more farm dams in Australia. They are unevenly distributed and range in size from puddles to beyond $1 \times 10^6 m^3$. The average size, at least in southwestern W.A. (W.A. Dept. of Agriculture,

*Based on paper presented at 47th ANZAAS Congress, Hobart, 1976.

personal communication) is 1.5 x $10^3 m^3$, but private irrigation dams in northeastern N.S.W. often have volumes greater than 1 x $10^5 m^3$. In this state the greatest concentration of small dams (volume <1 x $10^4 m^3$) is in the Central West, Riverina and Cumberland Plain, while larger dams (volume >1 x $10^4 m^3$) are in coastal areas (Fig. 1). By contrast, in southwestern W.A. dams in inland areas tend to be larger in order to offset losses by evaporation.

The method of construction and geomorphological features of a farm dam probably have some influence on its limnological characteristics. For instance, excavated dams, with their square to round shape and steep sides, are flat bottomed and have littorals which are minimal in extent. Littoral vegetation is sparse or absent. On the other hand dams in gullies are triangular to dendritic in shape, and have a limited area of greatest depth and have a shallow and wide littoral often with dense growths of macrophytes, at least at the upstream end. Water is likely to be much more turbid in excavated dams while protection from wind is typically greatest in gully dams.

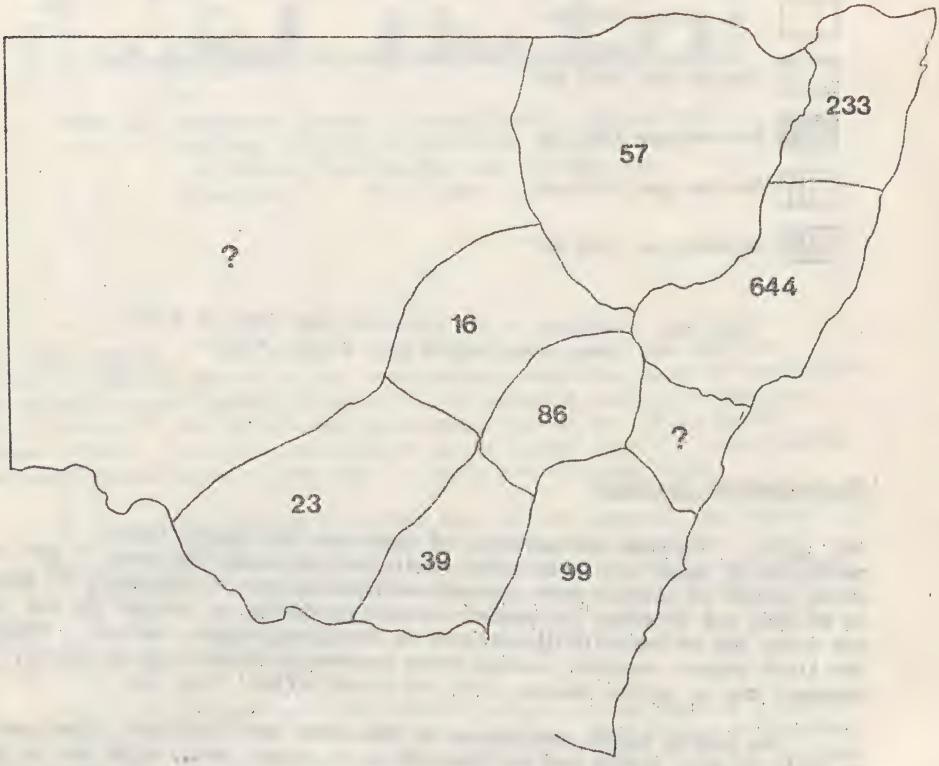

Fig. 1a. Number of large farm dams (irrigation) in N.S.W. (Data supplied by N.S.W. Dept. Agriculture.)

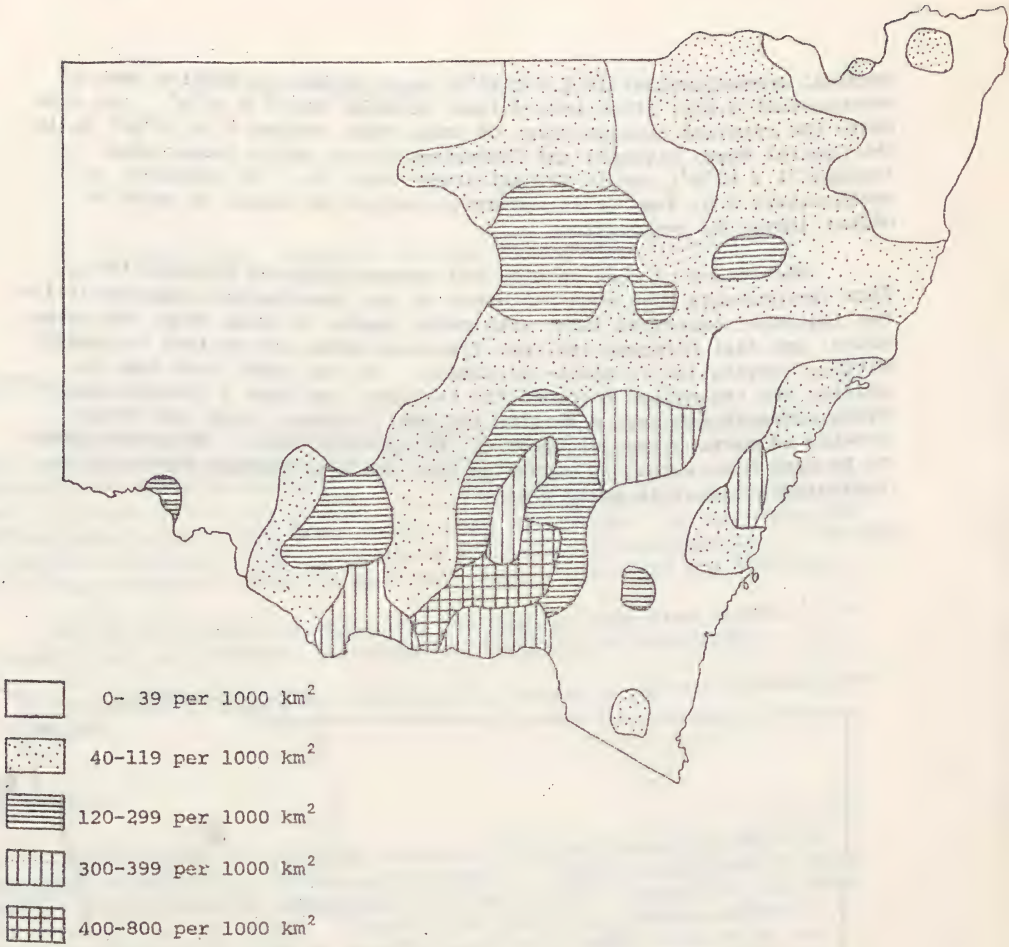

Fig. 1b. Density of all types of farm dams in N.S.W. (Data supplied by W.C. & I.C., N.S.W.)

Physiochemical features

(a) Light Perhaps the majority of farm dams are highly turbid, particularly those in clayey soils or visited regularly by stock. If water income is largely from underground sources then transparency is likely to be high and if there is extensive plant growth in and around the dam then the water may be markedly discoloured by dissolved organic matter. Whatever the light regime seasonal changes occur because of phytoplankton blooms, seasonal use by cattle (Walker 1974) or flood inflows (Fig. 2).

The highly turbid conditions of farm dams have important repercussions on their biology (Bayly and Williams 1973). Light penetration may be so small that primary production is suppressed and heating is restricted to the upper decimeters.

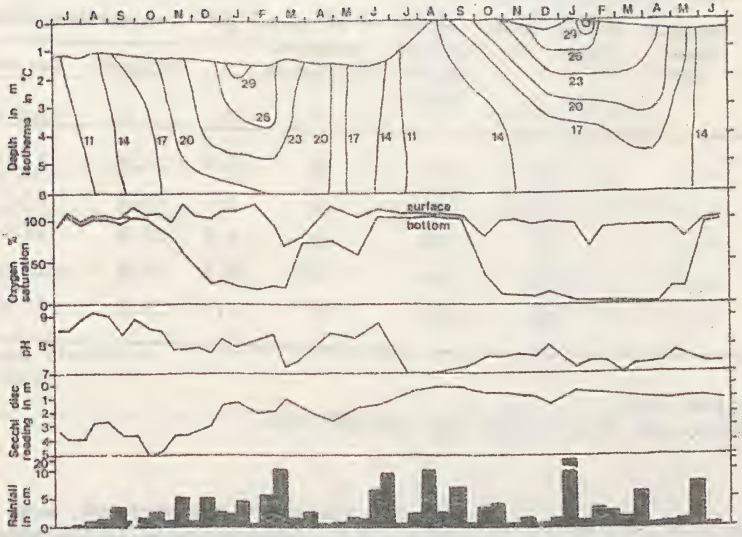
J A S O N D J F M A M J J A S O N D J F M A M J
Depth in m of isotherms in °C
11 14 17 20 29 26 23 20 17 14 11 14 29 26 23 20 17 14
Oxygen saturation in %
surface
bottom
pH
Secchi disc reading in m
Rainfall in cm

Fig. 2. Seasonal changes in water level, temperature, surface and bottom dissolved oxygen content, pH, Secchi disc reading and rainfall for reservoir 3. From Timms (1970a).

(b) Temperature The surface temperatures of small farm dams are likely to reflect prevailing air temperatures more than those of reservoirs. For example on the Central Coast of N.S.W. seasonal range in a farm dam was 11.1 - 33.7°C but in a nearby small reservoir it was 12.4 - 26.5°C (Timms 1970a). Surface temperatures may be warmer than air temperatures for considerable periods (see Fig. 3, Bayly and Williams 1973).

It is usually thought that farm dams do not stratify, but anyone who has swum in a turbid one on a hot day can testify otherwise. As Bayly and Williams (1973) point out, stratification is usually transitory but in deeper/highly turbid/protected dams it may persist for weeks or months (Fig. 2). Stratification can be surprisingly marked (.e.g 10°C change in 2 m in a farm dam in W.A. - Morrissy 1970) and may occur in quite shallow dams (Table 1).

There is little doubt that stratification in farm dams is enhanced by the turbid conditions. As such it influences, directly or indirectly, many biological properties such as suitability of the dam for fish culture.

TABLE 1. Some Physiochemical features of five farm dams at Gloucester, N.S.W.*

Dam	Maximum Depth (m)	Secchi Disc Depth (m)	Water colour in Pt units	% of area occupied by plants	pH	Temperature (°C)	
						Surface	Bottom
1	8.5	81	84	5	7.5	26.0	12.0
2	5	150	56	10	7.2	21.3	15.9
3	2.5	41	168	20	6.0	22.0	17.0
4	1.35	42	320	50	6.2	21.5	19.3
5	1.0	50	280	95	6.0	19.5	17.6

*Original data - temperatures read between 800 and 1100 hrs.

(c) Oxygen In general, oxygen concentrations are very variable, with higher values in summer than in winter, in the afternoon than in the morning, and at the surface than on the bottom (Bayly and Williams 1973). Even in shallow dams bottom water may be deoxygenated (Walker 1974). Deeper farm dams may behave like reservoirs and have deoxygenated hypolimnia during summer (Fig. 2).

(d) Fluctuations in Area and Volume As might be expected from the use made of dams, areas and volumes fluctuate considerably, even in the equable climate of Tasmania (see Weatherley 1958a). In the high evaporation areas of W.A. and S.A. dams may need to be 6 m deep in order to retain some water all year round. In such areas minima are likely to be <1% of maxima, even in normal years.

These fluctuations, besides making the establishment of littoral vegetation difficult or impossible, are likely to influence water chemistry.

(e) T.D.S. The T.D.S. concentration in farm dams is typically much less than 2000 ppm, otherwise they defeat the purpose for which they were constructed. Values fluctuate considerably because of volume variations and are influenced by rainfall (really P/E ratios) and rates of water renewal (Timms 1970b). The magnitude of fluctuations is similar to those in reservoirs and many lakes (Table 2).

TABLE 2. Seasonal percentage fluctuation in salinity in some inland waters.

Water bodies	Number studied	Range	Mean	Source of data
Farm Dams - (a)	5	32 - 156	83	Timms 1970b & unpublished
Farm Dams - (b)	6	57 - 137	96	Walker 1974
Reservoirs - (a)	6	19 - 97	56	Beer, in Williams 1967
Reservoirs - (b)	4	105 - 140	125	S.A. Eng. & W.S. Dept, in Williams 1967
Closed freshwater lakes	4	17 - 94	53	Bayly & Williams 1966

(f) pH It seems that most farm dams are neutral or alkaline, but should appreciable amounts of dissolved organic matter be present then acid conditions are likely (see Table 1). Variations may be largely seasonal, e.g. in winter rainfall areas, or completely irregular and related to the incidence of flood inflows, e.g. as in eastern N.S.W. (see Fig. 2). Considerable spatial heterogeneity in pH can occur, mainly during spring-summer when spatial rates of photosynthesis may be particularly uneven (Table 3).

TABLE 3. Spatial variation in pH in St. Lucia Pond, Queensland*

Date	Open water		Weedbeds	
	Bottom	Surface	H^+ only	$H^+ + L^{\emptyset}$
30 July	8.0	8.1	8.1	8.1
2 Oct.	8.4	9.1	9.7	9.2
5 Nov.	8.0	8.0	9.7	9.3

* from Timms 1965
$^+$ H = *Hydrilla verticillata*
$^{\emptyset}$ L = *Limnanthemum indicum*

(g) Nutrients Many farm dams, particularly those draining improved pastures or agricultural land or visited regularly by stock (Walker 1974), have high levels of nitrates and phosphates (Table 4). As in many Australian lakes and reservoirs (Williams and Wan 1972), values are often greater than those (N = 0.3 ppm, P = 0.015 ppm) considered to characterize eutrophic conditions in lakes in the northern hemisphere (Sawyer 1966).

TABLE 4. Nutrient concentrations in some dams in the Onkaparinga Catchment, S.A.*

Catchment Use	PO_4 in mgl^{-1}	NO_3 in mgl^{-1}
Moderate Grazing (3 dams)	0.11	2.05
Intense Grazing (1 dam)	0.44	35.46
Mixed Grazing and Horticulture (4 dams)	0.14	1.97
Natural Scrub (2 dams)	0.01	0.08

* from Moore 1974

(g) Overview While farm dams, may be similar morphologically to reservoirs, there are few other similarities. Temperature, oxygen concentration, volume and pH fluctuate more in farm dams, light penetration is much less and nutrient concentrations are much higher.

In general environmental conditions are more harsh than in reservoirs. The most limiting factor in farm dams is turbidity which limits photosynthesis and influences temperature and oxygen concentration and biological features.

Biological Features

(a) Phytoplankton As far as I am aware, there has been no systematic study of phytoplankton in farm dams; only blooms (Weatherley 1958a, Timms 1970a) or the presence of toxic algae (e.g. Aplin 1967) have been noted.

It is usually believed (e.g. Swingle and Smith 1950) that turbidity restricts phytoplankton numbers. Thus Grier (in Wood 1974) reports more phytoplankton in Lake Burley Griffin (a big farm dam!!) during periods of decreased turbidity, but on the other hand Weatherley (1958) noted that large populations can occur despite high turbidity. Clearly even basic information is lacking.

(b) Zooplankton By contrast to the situation with phytoplankton, there have been sufficient studies to at least indicate species composition and distribution in larger dams, though data on smaller dams are meagre. In eastern N.S.W. (see Timms 1970a, 1970c) zooplankton communities consist of a species of *Boeckella*, perhaps a *Calamoecia* sp., one or two cyclopoids usually including *Mesocyclops leuckarti*, and one or two cladocerans from the genera *Daphnia*, *Ceriodaphnia*, *Bosmina* and *Moina*. In smaller dams the picture is not so clear - it may be similar or less diverse [as in Walker's dams (Walker 1974)] or quite different (e.g. in the smaller farm dams at Gloucester ciliates and rotifers dominated while the few crustacean species present were littoral forms).

Seasonal changes may be marked and either regular or if irregular then often controlled by the passage of floods (see Fig. 3 in Timms 1970a, Weatherley 1959a). It seems that high turbidity *per se* has no adverse effect on numbers or diversity (Walker 1974). The influence of variable oxygen concentration, intermittent stratification and high nutrient levels have not been studied.

(c) Benthos Again I turn to Weatherley's (1958a, 1959b) Tasmanian studies for basic information. He found that the dominants were chironomids and oligochaetes (and gastropods, if no fish) and that biomass was as high as 60 gm^{-2}, but usually <5 gm^{-2}. In Walker's (1974) six dams there were two species of chironomid (*Cryptochironomus* sp. and *Procladius* sp.) plus an oligochaete (*Antipodrilus davidi*). By contrast my unpublished work on a few dams in eastern N.S.W. suggests that benthos is usually sparse (*ca* 1 gm^{-2}) and consists mainly of *Chaoborus* sp. In dams that fluctuate greatly in area, much of the benthos is killed during drawdowns (Weatherley 1958a).

In southwestern W.A. a notable benthic species is the marron *Cherax tenuimanus* (Smith) (Morrissy 1970, 1975).

(d) Littoral plants No data are available on littoral plant communities, although there is information (Ashton 1973, Sainty 1973) on the biology of most species. In my experience it seems that, if plants grow at all, there are different dominants in circumscribed areas, probably reflecting soil types and climatic regimes. Ecological zones are often obvious, but I am unaware of any work on their structure, let alone on functional attributes.

(e) Littoral animals The littoral of a farm dam may be bare earth, rocky, sparsely or densely covered with vegetation which may be submerged, floating or emergent. These possibilities, together with water level fluctuations, water chemistry, the age and size of dam, the element of chance, etc., summate to a complex situation, difficult to study. So no wonder we lack published work.

Two unpublished studies are available for consideration. One, on five farm dams in northeastern N.S.W. (Table 5) suggests diversity might be related to the abundance and diversity of littoral plants, but not to dam size or age.

TABLE 5. Littoral invertebrates in five farm dams at Gloucester*

Taxon			Dam 1	Dam 2	Dam 3	Dam 4	Dam 5
Porifera		- sponges	-	1	-	-	-
Platyhelminthes		- planarians	1	1	-	-	-
Annelida	- Oligochaeta	- f.w. earthworms	1	1	-	-	-
	Hirudinea	- leeches	1	-	-	-	-
Crustacea	- Ostracoda	- seed shrimps	3	4	1	1	1
	- Cladocera	- water fleas	3	7	8	2	4
	- Copepoda	- copepods	2	4	1	2	4
	- Decapoda	- shrimps	1	1	-	1	-
Insecta	- Odonata	- dragons & damsels	2	3	1	3	3
	- Hemiptera	- bugs	8	6	3	4	3
	- Coleoptera	- beetles	3	2	1	3	1
	- Trichoptera	- caddis larvae	2	2	-	1	1
	- Diptera	- fly larvae	1	3	4	3	4
	- Lepidoptera	- moth larvae	-	1	-	-	-
Arachnida	- Araneida	- spiders	1	1	-	1	1
	- Hydracarina	- water mites	-	2	2	1	-
Mollusca	- Gastropoda	- snails	1	4	1	2	-
Total number of species			30	43	24	26	23
Relative abundance of littoral plants			+	+++	++	++	+++
Number of species of plants			11	19	9	11	12
Size of dam $m^3 \times 10^3$			59	25	5	0.5	0.05
Age (in years)			11	19	>25	>40	>40

*Original data

The other by Walker (1974) on six Tasmanian dams is based on more extensive collections and shows the deleterious effect of stock usage (via their depressing influence on macrophyte abundance) on macroinvertebrate diversity (Table 6). In one dam (Dam F) Walker explained the low diversity and different communities structure by the unique presence of fish (Tench). This author also noted seasonal changes in diversity as temperature and degree of inundation of littoral vegetation changed. There is in addition a biogeographical factor operating, as the Tasmanian dams have a greater diversity than the N.S.W. ones (this phenomenon of course is not restricted to farm dams). The situation is undoubtedly more complex than indicated here, so that a rewarding study awaits the ecosystem analyst.

TABLE 6. Numbers of littoral invertebrate species and some influencing factors in six Tasmanian farm dams[+]

Parameter \ Dam	A	B	C	D	E	F[ø]
Number of species of littoral invertebrates	33	60	49	48	63	42
Relative abundance of littoral plants*	+	+++	++	++	++	+++
Number of species of littoral plants*	1	2	5	3	2	2
Relative influence of stock*	+++++	+	++	++	+++	+++
Relative degree of turbidity*	++++	++	+	+++	++	++

[+] adapted from Walker (1974)

* recorded on a five point scale "+" to "+++++" from least to most abundant/influence/turbid respectively

[ø] Fish (Tench) present

(f) Fish Most dams lack fish because of the limited opportunities for them to colonize isolated waters. Fish are, however, often introduced artificially (see later) but apart from productivity studies, their influence on dam communities has been little studied. Some, particularly the European Carp have obvious deleterious effects, but for others the influence is less obvious to the casual observer. In this regard, I have already noted Walker's (1974) observation on the effect of Tench on the diversity and structure of the littoral macroinvertebrate community.

(g) Succession Most farmers realize that their dams change with time, if from no other observation than that vegetation develops or siltation occurs. These processes usually take many years, but less obvious changes can occur quite quickly. Thus Weatherley (1958b) records an initial plankton bloom which was probably maintained on decaying organic matter (the dam site was heavily grassed before filling) and then it was 2½ years till another bloom, presumably maintained on phytoplankton, occurred. These changes are in essence those that have been observed for new reservoirs in Russia (Rzoska 1966), but occurring in a much shorter time span. In excavated dams, by contrast, the initial bloom does not seem to occur, although zooplankters may quickly colonize the new water (Timms unpublished). These changes, and other more subtle ones, need detailed study.

Multipurpose use

There is not much incentive to use farm dams for any other purpose than storing water. However, thoughtful and resourceful landholders can enhance the visual attractiveness of this land, provide home-based recreation (I know of a grazier who water-skies on his dam!) and produce gourmet food. In other words, it is possible to grow yabbies, to raise fish and to encourage water birds to use dams.

(a) Yabbies In the southwest of W.A. an important amateur fishery is based on the marron *(Cherax tenuimanus)*. This yabbie does well in clear water gully dams of the high rainfall areas and also in the white clay dams of the wheat and sheep belt (Morrissy 1970).

In eastern Australia yabbies (usually *Cherax destructor*) may grow on an *ad hoc* basis or can be successfully cultured, but farming is not yet economical.

(b) Fish Weatherley (1958b) showed it is possible to raise fish in farm dams but "unaccountable failures might occur". In southeastern Australia trout, particularly Rainbow Trout, flourish in deeper, cold water dams, while a variety of native fish including Murray Cod, Golden Perch, Silver Perch and Catfish will grow well if conditions are suitable. Advice and young fish are obtainable from appropriate state authorities. Although a recreational fishery is possible in farm dams, few farmers seem to try, and of these, many just throw fry in and hope for the best. Those that manage their stocks usually succeed. At this stage commercial production of fish in farm dams is not feasible.

(c) Waterfowl In general waterfowl require shallow weedy areas; these are uncommon on most farm dams because in order to reduce evaporation losses dams are usually designed so that littoral areas are steep. However it is possible in many cases, as with gully dams or in higher rainfall areas, to provide shallows for birds. With the addition of shrubs and a few trees dams provide aesthetic interest as well as hunting possibilities.

Conclusions

The major limnological characteristics of farm dams are perhaps their high turbidity and variability. But these generalities and others mentioned above hide a multitude of unknowns. From the limited data available it seems that the major factors influencing the limnology of farm dams could be, in order of importance (a) land use patterns - particularly the effect of stock in and near dams, (b) catchment characteristics, e.g. soil types, vegetation regimes, run-off and (c) climate. Size and age (within limits) are possibly of minor importance.

An organized research programme, particularly on production and fish rearing, combined with an active extension service to farmers on the possibilities of multipurpose use, is urgently needed.

Acknowledgement

I wish to thank the 1976 Zoology IIa class of Avondale College for field assistance at Gloucester.

References

Aplin, T.E.H. (1967). Water Blooms. *J. Dept. Agric. West. Aust.* 8(11), 472-474.

Ashton, H.I. (1973). "Aquatic Plants of Australia". (MUP: Melbourne).

Bayly, I.A.E. and Williams, W.D. (1966). Chemical and Biological Studies on some saline lakes of South-East Australia. *Aust. J. mar. Freshwat. Res.* 17, 177-228.

Bayly, I.A.E. and Williams, W.D. (1973). "Inland Waters and their Ecology". (Longman: Melbourne).

Macan, T.T. (1963). "Freshwater Ecology." (Longmans: London).

Moore, S.D. (1974). Changing Land Use Increases Nitrate Nitrogen and Phosphate Concentrations in Farm Dams. (Dept. of Agric., South Aust.)

Morrissy, N.M. (1970). Report on Marron in farm dams. *Fish. Rep. West. Aust.* 5, 1-34.

Morrissy, N.M. (1975). Spawning Variation and its Relationship to Growth Rate and Density in the Marron *Cherax tenuimanus* (Smith). *Fish Res. Bull. West. Aust.* 16, 1-32.

Rzoska, J. (1966). The Biology of Reservoirs in the U.S.S.R. in "Man-made Lakes". (Ed. R.K. Lowe-McConnell) (Academic Press: London).

Sainty, G.R. (1973). "Aquatic Plants. Identification Guide." (Water Conservation and Irrigation Commission, Sydney).

Sawyer, C.N. (1966). Basic Concepts of Eutrophication. *J. Water Pollut. Control Fed.* 38(5), 737-44.

Timms, B.V. (1965). Ecological studies on the Entomostraca of some lentic environments of south-east Queensland with special reference to *Boeckella minuta* Sars (Copepoda: Calanoida). Hons. Thesis, Univ. Qld.

Timms, B.V. (1970a). Aspects of the Limnology of Five Small Reservoirs in New South Wales. *Proc. Linn. Soc. N.S.W.* 95, 46-59.

Timms, B.V. (1970b). Variations in the Water Chemistry of Four Small Lentic Localities in the Hunter Valley, New South Wales, Australia. *Aust. Soc. Limnol. Bull.* 3, 36-9.

Timms, B.V. (1970c). Chemical and zooplankton studies on lentic habitats of north-eastern New South Wales. *Aust. J. mar. Freshwat. Res.* 21, 11-33.

Walker, W.G. (1974). An investigation of farm dams in the Copping Area of Tasmania. University of Tasmania, Honours Thesis.

Weatherley, A.H. (1958a). Tasmanian farm dams in relation to fish culture. *C.S.I.R.O. Div. Fish. Oceanogr. Tech. Paper No. 4*, 24 pp.

Weatherley, A.H. (1958b). Growth, production, and survival of brown trout in a large farm dam. *Aust. J. mar. Freshwat. Res.* 9, 159-66.

Williams, W.D. (1967). The chemical characteristics of lentic surface waters in Australia in "Australian Inland Waters and their Fauna: Eleven Studies" (Ed. A.N. Weatherley) (A.N.U. Press: Canberra).

Williams, W.D. and Wan, Hang Fong (1972). Some Distinctive Features of Australian Inland Waters. *Wat. Res.* 6, 829-36.

Wood, G. (1975). An Assessment of Eutrophication in Australian Inland Waters. *A.W.R.C. Tech. Paper No. 15.*

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ARE STRIKES ALWAYS A NUISANCE - OR "IMPACT OF THE SEWAGE WORKERS' STRIKE ON THE RIVER CLYDE"

by T. Petr

Dept. of Zoology, Monash University, Clayton, Vic., 3168

Studies carried out during and after the strike support the view that aquatic ecosystems can recover from severe or catastrophic short-term pollution much more rapidly than from lower levels of chronic pollution, probably because benthic communities are influenced by stream bed conditions more than by flow water quality. Five months after the end of the eight-week strike biological conditions in the freshwater and marine sections of the river were almost back to normal, as predicted at the strike's end. Exceptional flows during and after the strike minimized potential damage and made this recovery possible. Also the species present at the outset were restricted and fairly pollution tollerant. Much more severe damage would have resulted under warm summer conditions and low flow rates. The incident illustrates the vulnerability of a system with many treatment plants dependent on a single sludge disposal facility. Direct injection of O_2 can be of value in protecting vulnerable river stretches for a limited period, but would be impractical over the 30 km length of river affected by the strike.

(D. Hammerton (1975): Effluent, Water Treatment J., 15: 278-287.)

BOOK REVIEWS

"NEW ZEALAND LAKES"

EDITED BY V.H. JOLLY AND J.M.A. BROWN

Auckland University Press and Oxford University Press, Auckland, 1975, 388 pp., A$26.25.

REVIEWED BY I.A.E. BAYLY, MONASH UNIVERSITY

This book is edited by the late Dr. V. Hilary Jolly and Dr. J.M.A. Brown, Department of Botany, University of Auckland.

Hilary Jolly's death in October 1975 (shortly before the appearance of the book) represented a sad and heavy loss to limnologists in New Zealand and Australia, but now we are, to an extent, compensated by a major posthumous contribution which owes much to her energy, vitality and devotion to limnology.

The scope of the book is very broad: geomorphology, physics, chemistry, phytoplankton, zooplankton, macrophytes, benthos, nekton and lacustrine birds are all included. It would be no easy matter with our present state of knowledge to put together a book of matching comprehensiveness on Australian limnology.

This book will find its greatest use amongst professional limnologists, especially those in New Zealand and Australia, and also those in the northern hemisphere who wish to expand their horizons and learn more about the peculiarities of southern hemisphere biota and biogeography. It will also be useful to students in New Zealand and Australia for reference purposes. It is certainly not, however, a student textbook of limnology - it is too lacking in the development of general limnological principles and has too much descriptive and expatiatory content on the differences between, and peculiarities of, various New Zealand lakes to serve this purpose.

The quality of the printing and of the half-tone plates and diagrams is good throughout; it is an attractively produced book.

The first three chapters deal with geomorphology, sedimentology and the origin of lake basins. Chapter 1 gives the book a good start by using New Zealand lakes to illustrate general principles. (This meritorious approach unfortunately seems to become lost in most of the ensuing chapters.) It is very well illustrated although in places less well written; several sentences require more punctuation for easy reading. There is a mismatch between the text reference to Figure 1.17 on page 51 (Lake Leman, Switzerland) and the caption to Figure 1.17 which identifies the figures as pertaining to Lake Wakatipu. Chapter 2 is well written and includes several figures with extensive, informative and self-contained captions. Chapter 3 lacks appropriately interspersed references, and

the author could, with advantage, have made the point that the interpretations which he now advances represent a substantial modification of those outlined by him in 1963 (not in *Proc. N.Z. Geol. Soc.* as stated on page 343, but in *Proc. N.Z. Ecol. Soc.* No. 10); it is now made clear, for example, that Lakes Tikitapu and Rotoma lie outside Haroharo Caldera and not within it as previously stated (op. cit. p. 55). With respect to Figure 3.1, what is marked within the frame of the figure as "Okataina Caldera" is apparently the same as that referred to in the caption and text as "Haroharo Caldera". The application of the name "Haroharo" to one of two different rhyolitic eruptions within the Haroharo Caldera, tends to add to the confusion.

Chapters 4 - 6 deal with physical characteristics. In the first of these, the statement (p. 85) that "Seechi (sic.) depth was positively correlated with primary production" should read "... negatively (or inversely) correlated ..." The chapter on thermal conditions, although making some good points, contains some unfortunate lapses. The caption to Figure 5.1 refers to "the characteristic knee developed in the profile at *the maximum plane of temperature decrease*" (my italics). Presumably the italicised section should read "the plane of maximum rate of decrease of temperature", as quoted from Hutchinson in the text below the figure. However, even then the statement would be incorrect; the "knee" (defining the upper limit of the metalimnion) is distinctly and measurably above the plane of maximum rate of change of temperature. Neither can I agree with the statement (p. 99) that "In tropical countries .... lakes do not stratify unless very large and deep"; oligomictic lakes (normally stratified and mainly tropical) are commonly small or very deep, or both. It is stated (p. 99, l. 9-10) that the temperature variation between top and bottom is less in Lake Hayes than in Lake Tikitapu but Fig. 5.6 shows the reverse condition.

The conductivity data given in Table 7.1 are unbelievable. The unit is stated to be "millisiemens/cm", i.e. 10^{-3}S/cm. On this basis the most dilute water recorded (lower limit of Westland lakes) had a conductivity (K_{25}) of 2100 µS/cm (to use a unit more familiar to limnologists). This would mean a salinity probably in excess of 1000 mg/l which is clearly incorrect. It seems the unit should in fact be 10^{-5}S/cm (or µS/cm x 10) this would be the same as the perfectly valid but unfamiliar unit ms/m (sic., correctly mS/m) quoted on page 115. It is difficult to agree with the statement (p. 112) that "All of the glacial waters are relatively low in nutrient content as indicated by the data .... in Table 7.1". These lakes may well be low in nutrients but no data for nutrients, in any normal limnological sense of the word, are given in Table 7.1. The unit chosen for Table 7.3 (g/m^3) is obviously inconveniently large. It is stated on p. 121 that "... all the caddisfly larvae except *Psilochorema aureola*, occur elsewhere in the lake ....", but Table 7.4 shows this to be the case for *Psilochorema nemorale* —there seems to have been a transposition of specific names.

Chapter 8 consists of an interesting and competent interpretive account of the chemistry and biology of the main volcanic lakes of the North Island. The use of the unit "cusecs" (p. 133) amongst otherwise exclusively metric units is perhaps a little incongruous. The statement (p. 135) that "The monovalent:divalent cation ratio and Ca:Mg ratio apparently have no well-established biological consequences ...." is certainly contestable. The two references quoted in support of this contention refer to algae. Ringer showed otherwise for animals as early as 1883.

A good account of the phytoplankton of the impounded lakes of the Waikato River is provided in Chapter 9. Chapter 10 provides a tentative nutrient budget for the eutrophic Lake Rotorua. It is difficult to know

whether the statement (p. 156) that "It is inevitable that rapidly growing communities will often outstrip the capacities for sewage treatment ....." shows realism, cynicism, despair or defeatism!

Chapter 11 on eutrophication and the trout environment is a concise and instructive one. However, many limnologists will disagree with the statement that "The measurement of the carbon assimilation rate, with ^{14}C, has the advantage of being a reasonably easy technique". Failure to state the units for P_{max} values on pages 161-162 is annoying.

Three chapters (12, 13 and 14) are devoted to phytoplankton. (Why, in view of this, three subsequent chapters on macrophytes should be referred to as "plant studies" rather than phytobenthos or macrophyte studies is not at all clear!) The first of these is too discursive to be of interest to a "general reader" but is presumably of value to those actively engaged in phytoplankton research in New Zealand. The statement on page 191 concerning the inhibition of *Dinobryon divergens* by high concentrations of phosphate was probably justified at the time it was written, but it may be noted in passing that more recent work (*vide Limnol. Oceanogr.* 21, 646-658) shows that phosphorus is not toxic to *Dinobryon* even at high concentrations.

Reservation must be expressed about several statements in Chapter 15 concerning the distribution of zooplanktonic organisms. It is difficult to agree with the proposition (p. 209) that "representatives of many cosmopolitan families and genera are totally lacking" because of the "long period of geological isolation" of New Zealand. In fact, I cannot think of one "cosmopolitan" family or genus of zooplanktonic organism that is absent from New Zealand lakes; in the Rotifera there are none, in the Cyclopoida *Cyclops* s. str. is absent but is not a cosmopolitan genus (it is missing from the Australasian, Ethiopian and Neotropical regions), in the Calanoida *Boeckella* and *Calamoecia* occur instead of *Diaptomus* not because of the isolation of New Zealand but because of its geological affinities with Gondwanaland and, in any event, *Diaptomus* is not a cosmopolitan genus. Neither can I agree with the statement (p. 209) that the presence of *Boeckella* in Mongolia is based on "an unconfirmed report"; Sars' 1903 record was reconfirmed by Rylov in 1933 and Kiefer in 1937. It is definitely there and, moreover, a geological mechanism has been proposed (*vide Science* 184, 1179-1181) which makes this hitherto mysterious distribution now comprehensible. Thirdly, even allowing for the fact that *Daphnia carinata* s.l. is really a cluster of species (D. Hebert, unpublished), the statement (p. 214) that it is "virtually world-wide in .... distribution" is scarcely justified; in addition to Australasia it has been recorded only from S.E. Asia.

The indication (p. 211) that the nauplii of *Calamoecia lucasi* eat larger particles (mean size 11.2 µm) than do the adults and copepodites (mean 9.6 µm) seems a bit hard to swallow.

It would be interesting to know what the curve for the zooplankton of "a cool temperate lake" (Fig. 15.7) is based on. With its well-marked spring and autumnal peaks, it looks suspiciously like the "classical" curve of phytoplankton density which Hutchinson (1967) regards as an extrapolation from oceanography which has only limited value for lakes.

Chapters 17 and 18 are an exception to the rather mundane descriptive approach adopted in much of the biological portions of the book. In these two chapters a rather more dynamic approach is taken to problems involving

the distribution and abundance of lacustrine macrophytes. However, the statement in chapter 18 (p. 267) that "If the quantitative requirements for nutrients by two species vary then they will overlap in their range of distribution" is an extraordinary one.

In Chapter 19 the authors mention (p. 279) the interesting occurrence of the mysid *Tenagomysis* (misspelt *Tenagonysis* on line 16) in certain dune lakes along the west coast of the North Island but fail to mention Hodge's 1964 (*N.Z. Jl. Sci.* 7, 387-395) record of *T. chiltoni* from Lake Oturi.

It is sad to read in the introduction to Chapter 20 that "Most published information on [N.Z.] benthic faunas is based on ... an effort to gauge their suitability for introducing trout.". Surely the study of lacustrine benthos is worthwhile for its own intrinsic scientific interest or for its applied potential in problems other than that of keeping the guts of alien species in state of distention. The indiscriminate liberation of smelt *(Retropinna)* "because of their importance as trout food" (p. 295) is another manifestation of the same syndrome, and as pointed out (p. 295) "This is unfortunate and makes studies of the native freshwater fish fauna more difficult.". R.A. Falla notes, with respect to birds, that (p. 323) "Community concern for, and appreciation of, the importance of diversity in natural or self-renewing habitat can extend much further than just one sectional need for recreation.". One can easily say Amen to that, and wonder why, to men, it is so much more readily appreciated above the air/water interface. Presumably if our foetal gill slits persisted into adulthood it would be the other was round. Falla further notes (p. 325) "It is somewhat ironic that several indigenous bird species and at least one fish genus *(Anguilla)* have had to bear the brunt of a hundred-years war waged in the supposed interests of introduced salmonids.".

Returning to Chapter 20, here we find too much detailed description and not enough by way of synthesis and comment on the general principles emerging from a comparative study of the benthos of five lakes. It seems a pity that in this chapter oligochaete worms, which are always a significant component of the fauna, are usually no further resolved taxonomically. This approach seems rather unbalanced when viewed against the rather fine resolution of the chironomids. Likewise, in Chapter 19, nematodes are always referred to as such despite the fact that ample expertise is available within the DSIR Soil Bureau for positive identification of at least the major components. In these two areas it seems that New Zealand limnologists are missing out on an opportunity to provide several pieces of the zoogeographical jigsaw puzzle.

It is stated on p. 290 that small numbers of benthic species are due to "the youth and ephemeral (my emphasis) nature of our (N.Z.) lakes.". Whilst geological youth may well contribute to this paucity, it is difficult to see that in a well-watered country like New Zealand lakes are likely to be more ephemeral than those elsewhere and especially in Australia. The work of Timms shows that in Australia too, despite its greater geological antiquity, the benthic fauna is very limited in comparison with that reported from the northern hemisphere.

The chapter (23) by Falla on the lacustrine bird fauna is well written and full of interest. One learns, for example, that extant tracks on ridges running down to Lake Poukawa may have been formed by extinct moas visiting the lake to feed on *Hyridella* (Mollusca: Bivalvia), that in small lakes coots may provide one of the few natural checks on excessive growth of phytobenthos, and that there are distinct differences

between a "textbook grebe" and a grebe as it really lives in New Zealand. Further, the introduction of the Australian black swan in 1867 was probably not an entirely "new experience" for New Zealand lacustrine ecosystems; an extinct native swan flourished there not many centuries earlier."

One bizarre aspect of New Zealand limnology, not shared by Australia, is the corrosion of gulls' feet by near boiling acids and alkalis. The grisly statement appears (p. 335) that "In a sample of 30 [*Larus*] *scopulinus* 20 per cent showed some degree of corrosion to their feet, varying from complete loss of both feet, loss of all webbing and parts of toes, to some loss of webbing.". I have been unable to find an avian insurance policy detailing the amounts payable for each of these conditions, but the reason for this may lie in the further astounding statement that "In spite of this hazard the gulls remained attached to the site and in no other way seem to be disadvantaged by the thermal conditions."! One is tempted to pose the question: "What is the most invidious choice for a naked limnologist?" The answer is clear: the South American piranhas or the New Zealand acids.

There is a list of some 400 references. It is interesting to note that, although this includes papers published as late as 1974 (eight) and even 1975 (one), it does not include a comprehensive work, much of which deals with New Zealand lakes, published in 1973.

The proof reading of the book is generally adequate but included amongst the minor errors that slipped through are the following:

p. 226 Bayly 1972b for Bayly 1962b
p. 262 *Ctenopharyngoden* for *Ctenopharyngodon*
p. 268 *Myriophylums* for myriophylums
Potamogetons for potamogetons
p. 279 *Tenagonysis* for *Tenagomysis*
p. 281 Nemotoda for Nematoda
p. 287 ceratopogonic for ceratopogonid
p. 309 redds for reeds
p. 322 references for preferences
p. 342 "*varein*". for "*verein*".
p. 349 "Ecumbene" for "Eucumbene"

Despite some shortcomings, all practising limnologists in Australia should purchase this book.

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The following summaries of B.Sc.(Honours) thesis work at the Department of Zoology, Monash University, have been forwarded by Dr. Tomi Petr.

RUSSELL TAIT

A STUDY OF SOME VICTORIAN FARM DAMS WITH SPECIAL REFERENCE TO MICROCRUSTACEANS

A summer and winter sampling of 28 farm dams, to the southeast of Melbourne, showed the variable nature of their physical and chemical features, due to their nature of construction, use, water renewal, soil type and age.

Forty-three species of microcrustaceans were recorded from the dams. A computer analysis of the two samplings showed that certain associations existed between some of the microcrustaceans and similarly for some of the dams. Some microcrustaceans, *Acanthocyclops australis*, *Boeckella triarticulata*, *Daphnia carinata*, *Moina micrura* and *Duntevedia crassa* were found to occur in dams with restricted physical and chemical ranges. Some species, namely *Ectocyclops rubescens*, *Macrocyclops albidus*, *Acanthocyclops australis*, *Chydorus eurynotus* and *Pleuroxus aduncus* were found to have affinities with particular macrophytes. It was found that the age of the dams affected the presence of littoral macrophytes and microcrustaceans.

An increase in temperature and the presence of fish were found to cause a reduction in the size of the open water microcrustaceans. Notonectids were found to be excluded from the dams which had fish, due most likely to the fish out-competing them for food as the limiting resource.

Both the open water and macrophyte zones of the dams were dominated by one species of copepod and one of cladoceran, with the second dominant species of each more abundant in the macrophyte zone than in the open water.

At any one time there were, on average, 2.7 species of copepods and 1.6 species of cladocerans in the open water in both summer and winter. Several congeneric microcrustacean species were found to coexist in the dams, and in all but one case there was a size difference between the two species.

GREG SMITH

MERCURY IN CARP (CYPRINUS CARPIO) AND SEDIMENTS IN SOME EAST VICTORIAN WATERS

The results of the study of mercury concentrations in sediments and some fish in Lake Wellington and some adjacent waters (East Gippsland) indicate that at present the major source of mercury to Lake Wellington is the La Trobe River. In sediments of Lake Wellington the range of mercury concentrations was 0.05 to 0.42 ppm (dry weight), decreasing in concentration with the increasing distance from the La Trobe River mouth. In skeletal muscles of carp the mercury concentrations ranged from 0.01 to 5.95 ppm (wet weight), the highest concentrations being recorded for the oldest specimens. The maximum concentration of 5.9 ppm Hg observed for the muscle tissue of carp in Lake Wellington is comparable with concentrations observed in ecosystems with a very high level of mercury pollution, for example in Swedish lakes receiving effluents from chloro-alkali plants or directly below a paper mill. The present study suggests the walls of the intestine concentrate Hg from the gut content. The Hg level fluctuations may indicate that Hg is quickly removed from the walls, probably by the blood stream. It is suggested that carp could possibly serve as an indicator species for the concentrations of mercury in sediments.

JENNIFER L. MCAULEY

AN ECOLOGICAL STUDY OF THE AQUATIC INVERTEBRATES OF A SPHAGNUM BOG ON MT. BAW BAW, VICTORIA

A nine months' survey of the aquatic invertebrates of an alpine *Sphagnum* bog revealed the presence of over fifty-five different taxa of which eight are new. A number of aquatic animals were found to be associated with the submerged *Sphagnum* moss, while the emergent moss was inhabited by both aquatic and terrestrial taxa. Of particular significance was the abundance in the bog waters of microcrustaceans, isopods and molluscs despite the exceptionally low calcium concentrations. Certain animals, which are widely distributed in Tasmania, display, by their occurrence on Mt. Baw Baw, a northward extension of range. Both the species richness and species composition of the fauna were at variance with descriptions of "typical" *Sphagnum* bog communities in the northern hemisphere.

ALEXANDER MORISON

ASPECTS OF THE BIOLOGY AND COMPARATIVE ECOLOGY OF TWO SPECIES OF CHAOBORUS (DIPTERA:CHAOBORIDAE) IN LAKE ELIZABETH, VICTORIA

Two species of *Chaoborus* (Diptera:Chaoboridae) were found to inhabit Lake Elizabeth in the Otway Ranges, Victoria. Species 1, "the southern species", is univoltine with an extended spring and summer emergence period. Species 2, "the ornate species", is the smaller of the two and is multivoltine. It completes two life cycles over spring, summer and early autumn and shows an extended emergence period. Both species overwinter in a state of larval diapause in the 3rd or 4th instar. During summer stratifications 3rd and 4th instars of both species undertake a vertical diurnal migration concentrating in the epilimnion at night. After holomixis of the lake the larvae are dispersed throughout the water column. Only a small proportion of the benthic population of larvae participate in migration. No seasonal changes in the timing of the migration were observed. Benthic larvae of both species are found in both the littoral and profundal regions of the lake, but a seasonally persistent peak in abundance occurs at the top of the profundal zone. This is not the result of variation in substrate penetrability. The differences in the biology of the two species seem sufficient to indicate that they occupy separate ecological niches within the lake.

ANDREA R. FLETCHER

INTERSPECIFIC INTERACTIONS AND RELATIONSHIPS IN A BILLABONG COMMUNITY

The plant communities, which had been determined by application of phytosociological techniques, consisted of marginal, transitional and aquatic species groups. The aquatic communities could be separated into two floristic units which were dominated by *Eleocharis sphacelata* and *Triglochin procera* respectively. Animal species richness and population densities were greatest among *E. sphacelata* weedbeds. The large amount of organic matter in the substrate of these was probably a major source of nourishment for the abundant detritivores. Animals were more abundant in both types of weedbeds than in open water. Physico-chemical parameters appear to influence the general species composition, but do not determine their spatial distribution. Fluctuating water levels, observed during an autumn-winter drought, affected macrophyte zonation, animal species composition and variations in physico-chemical factors. Macrophytes provided greater spatial complexity and afforded protection from predation by the fish. The six fish species, and in particular *Gambusia affinis*, not only influenced the spatial distribution and abundance of macro-invertebrates but also the micro-invertebrate species composition. These conclusions were based on inclusion/exclusion experiments, stomach analyses of the fish and study of the fauna of a section of one billabong where fish were absent.

WENDY M. BLACKBURN

A STUDY OF FOREST LITTER IN RELATION TO A MOUNTAIN STREAM ECOSYSTEM IN VICTORIA

Total litter fall was estimated as 6.0 t ha^{-1} yr^{-1}. Bark and branch litter together constituted 66 per cent of the total litter fall, leaves contributed 25 per cent while the remaining fraction consisted of fruits and flowers, ferns and mosses. Due to the large mass of its input, bark and branch litter contributed the most energy to the stream, but sassafras (*Atherosperma moschatum*) and *Eucalyptus regnans* leaves had the highest calorific values per gram. Leaf packs within the stream consisted mainly of eucalyptus leaves and were colonised primarily by benthic detritivores such as stonefly and mayfly nymphs, caddis-fly larvae, amphipods and dipteran larvae. Preference by some organisms for leaf-packs was observed in experiments. The process of litter decomposition in aquatic systems was investigated both in the field and in the laboratory. Weight losses were measured from synthetic mesh bags for leaves of *Eucalyptus regnans*, *Nothofagus cunninghamii* and the exotic oak *Quercus* sp., and for bark of *E. regnans*. *E. regnans* and *N. cunninghamii* are important components of the vegetation surrounding the stream, while oak leaves, being an exotic species, were used as a reference. While bark and branch litter contributed the most biomass and energy to the stream, the processing rate of bark was very slow. Leaves, particularly of *E. regnans* are more readily processed than other litter. The oak leaves decomposed more quickly than either of the native species of leaves. Decomposition of litter occurs in two stages, leaching and fragmentation, that is, conversion of coarse particulate organic matter to dissolved organic matter and fine particulate organic matter respectively. In laboratory conditions a marked increase in percentage nitrogen content for all litter was found while calorific content showed no overall change and the organic content decreased very slightly.

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MASTER OF ENVIRONMENTAL STUDIES DEGREE COURSE UNIVERSITY OF ADELAIDE

Details of the 1978 Master of Environmental Studies Degree Course will be advertised in the National Press during May.

Information may be obtained from The Director, Dr. J.R. Hails, Environmental Studies, University of Adelaide, G.P.O. Box 498, ADELAIDE, 5001, S.A.

FOR LOVERS OF CARP

Here is a recipe from none other than Izaak Walton for all those in Australia who want to know what to do with carp.

"Take a carp, alive if possible, scour him, and rub him clean with water and salt, but scale him not; then open him, and put him, with his blood and his liver, which you must save when you open him, into a small pot or kettle: then take sweet marjoram, thyme, and parsley, of each half a handful, a sprig of rosemary, and another of savory, bind them into two or three small bundles, and put them to your carp, with four or five whole onions, twenty pickled oysters, and three anchovies. Then pour upon your carp as much claret wine as will only cover him; and season your claret well with salt, cloves, and mace, and the rinds of oranges and lemons: that done, cover your pot and set it on a quick fire, till it be sufficiently boiled; then take out the carp, and lay it with the broth into the dish, and pour upon it a quarter of a pound of the best fresh butter, melted and beaten with half a dozen spoonfuls of the broth, the yolks of two or three eggs, and some of the herbs shred; garnish your dish with lemons, and so serve it up, and much good do you."

(From *The Complete Angler*
by Izaak Walton)

A.S.L. BUSINESS

The Secretary/Treasurer has received from President Pollard a suggested outline of arrangements for the forthcoming Congress from John Lake. To avoid delays it is reprinted here in entirety.

SUGGESTED PROGRAMME FOR A.S.L. CONGRESS

FRIDAY - MAY 20TH: Arrive Lismore and register at BENELONG MOTEL, Glasgow Lane (100 m west of Post Office), Lismore. B & B, about $20 share room - about $15 single.

Also available - camping and caravan park near business section of town.

Need $5 deposit with requirements as soon as possible. (Cheques made out to A.S.L. John Lake's address is School of Cultural and Scientific Studies, Northern Rivers College of Advanced Education, P.O. Box 157, Lismore, N.S.W. 2480.)

SATURDAY - MAY 21ST: Meet at Northern Rivers College (walking distance from motel).

A.M.: Papers (to be organised by committee).

Lunch: Either at Lismore and District Workers' Club or counter lunches at several nearby pubs - go your own way.

Note: All members of A.S.L. and friends who supply their name in advance, will be made honorary members of the Workers' Club for the weekend and will be able to come and go as they please. The Club has excellent facilities.

P.M.: More papers (and perhaps A.G.M.)

7 p.m. to 12.30 a.m.: Dinner at Workers' Club - about $6 per head plus grog (steward service at bar prices). Dinner is an excellent SMORGASBORD - hot and cold food. For an extra $1 per head can have extra prawns (recommended) and can also have extra oysters at extra cost if desired.

Do you want -
a) basic at about $6 per head
b) basic plus extra prawns at about $7 per head or,
c) basic plus extra prawns and oysters at about $8 per head?

We will have the Club's special function room to ourselves and steward service at no extra cost.

SUNDAY - MAY 22ND: More papers to morning tea, then A.G.M. if not on Saturday afternoon. I strongly recommend A.G.M. on Saturday and then ready for field trip after late morning tea with sandwiches.

Then KIRKLANDS Bus(es) - 45 to a coach - $80 each coach, i.e. about $2 per head, to nearby rain forest, Minyon Falls and Creek for mid-afternoon B.B.Q. I can arrange food and grog for minimal cost.

MONDAY - MAY 23RD: Optional field trip (if smallish numbers - by cars) to Dune Lakes with Brian Timms who has worked here. This will be followed by a surf for those strong enough.

The college itself is still housed in old buildings but members may wish to inspect the T.V. studio and F.M. station run by the College. Anyone interesting in presenting some "science" for the 2NCR FM radio research hour should drop me a note.

The important things are to know how many will attend - their names plus $5 per head deposit, so that MOTEL, BUS AND WORKERS' CLUB can have firm bookings.

Travel to Lismore can be made by Airlines of N.S.W. - leave Sydney 4 p.m. - arrive Lismore about 6.15 p.m. on Fridays. (The airport is at Casino but Airlines bus to Lismore.)

From Brisbane by North Coast Airlines three times per day to Lismore light airstrip.

It is possible to return to Sydney either Sunday evening or Monday morning or evening.

Alternatively trains, buses or cars can be used to reach Lismore.

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LETTERS

To the Secretary/Treasurer:

Dear Rod,

Many thanks for the invitation to your 1977 Congress, I have included all the details in a newsletter to our members which was delivered prior to Christmas.

My delay in replying has been due to the uncertainty of the venue and dates of our next conference to which any interested members are cordially invited. It has been finalized for Taupo between May 18-20 which unfortunately almost coincides with your own conference but an International Aquatic Microbial conference being held in Dunedin during August made that month unsuitable this year.

Enquiries regarding our conference should be directed to:

Dr. Don Forsyth,
Freshwater Unit,
DSIR,
P.O. Box 415,
TAUPO.

Best wishes for the New Year.

(Laurel Teirney)
Secretary/Treasurer,
N.Z. Limnol. Soc.

Fisheries Management,
7-9 Donald McLean Street,
WELLINGTON 2, N.Z.

THE MENACE OF WATER HYACINTH AND OTHER AQUATIC WEEDS

This symposium was held in Adelaide on April 1st, 1977, and sponsored by the Water Research Foundation of Australia (S.A. State Committee). The programme was as follows:

4.00 p.m. Welcome: *Professor J.W. Holmes*, Chairman, S.A. State Committee, Water Research Foundation of Australia.

Official Opening: *The Hon. D.W. Simmons*, D.F.C., M.P., Minister for the Environment, S.A.

SESSION 1 - *Chairman: Mr. J.C. McColl, Director, Department of Agriculture and Fisheries, S.A.*

4.15 p.m. "The Australian Inland Aquatic Environment: a Background Review for Management Purposes". *Professor W.D. Williams*, Department of Zoology, University of Adelaide.

5.05 p.m. "Ecological Aspects of Water Weeds". *Dr. G.G. Ganf*, Lecturer, Department of Botany, University of Adelaide.

6.15 p.m. SYMPOSIUM DINNER

SESSION II - *Chairman, Mr. R.J. Shannon, Director, Engineering Services, Engineering & Water Supply Department; Commissioner representing S.A., River Murray Commission.*

7.30 p.m. "The History, Distribution and Control of Water Hyacinth in Australia". *Mr. R.K. Green*, Deputy Chief, Division of Plant Industry, Department of Agriculture, N.S.W.

8.20 p.m. "Chemical Control of Aquatic Weeds". *Mr. S.M. Bill*, Research Officer, Water Research Section, State Rivers and Water Supply Commission, Vic.

9.10 p.m. "Biological Control of Aquatic Weeds". *Dr. K.L.S. Harley*, Principal Research Scientist, Division of Entomology, C.S.I.R.O., Indooroopilly, Qld.

10.00 p.m. Round up - *Dr. W.G. Inglis*, Director, Department for the Environment, S.A.

10.10 p.m. Close of Symposium. *Mr. C.W. Bonython.*

10.15 p.m. Informal Discussion. Refreshments.

XIIITH INTERNATIONAL BOTANICAL CONGRESS

SYDNEY, 21-28 AUGUST 1981

Advance notice is given of the Sydney Congress. Section 10 of the Congress is "Freshwater and Marine Botany".

Anyone with an interest in plankton, freshwater algae or aquatic macrophytes who has any ideas on such matters as symposium topics, field excursions, etc., please contact Peter Tyler at Botany Department, University of Tasmania, Hobart.

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SUSTAINING MEMBERSHIP

The Society acknowledges with gratitude the support of:

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DEPARTMENT OF ZOOLOGY

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